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Chapter 9

EFFECT OF INPUTS ON PRODUCTION AND VARIABILITY OF INTRODUCED CHICKEN STRAINS AT FARM LEVEL: A CASE OF SMALL CHICKEN KEEPERS IN SELECTED AREAS OF TANZANIA

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ABSTRACT

This study investigated the effect of inputs on the production and variability of introduced chicken strains. The study applied the developmental research design, which involves provision of 25 six-week old chicks to 20 farmers in 12 on-farm testing sites. The study was carried out in Dodoma, Morogoro and Njombe regions to assess the effects of agro-ecological differences on production and production variability. Data used were gathered by using a structured questionnaire, direct measurement, farmers' and extension officers' records. A semi log multivariate regression model according to the Just and Pope Framework was applied in this study. Results from the mean function revealed that maize bran, rice bran, sunflower cake, minerals, frequency of medication, vegetables and house condition had significant effects on production in the production of both live chickens and eggs. Also, there is production variability attributable to inputs use and hence exposing farmers to risk. However, there was an inconsistent effect of input on production performance variability since some inputs were both variability increasing and reducing; that is, reducing in production of birds but, increasing in egg production for the same strain and vice versa. Therefore, it is likely that the full potential of the introduced strains requires standardized inputs for reduced variability. It is important to design strategies that will lead to performance stability. Such strategies should include the design of trials at farm level to evaluate the input mix for chicken with minimum effects on output variability.

INTRODUCTION

In agricultural production, risk in terms of variability is an inherent part of the production process and plays an important role in both input use decisions and production of output (Asche and Tveteras, 1999; Kumbhakar, 2002; Nalley and Barkley, 2007). Agricultural production face risk surrounding the production and marketing processes which are related to unpredictable weather variation (drought, frost, flood, and wind storm), input quality, pest and disease attacks, price fluctuations, new technology failure, and changes in government policies. In addition, agricultural risk can be categorized into two main types namely, production risk which is characterized by high variability of production outcomes and price risk (Wanda, 2009; Bizimana and Richardson, 2017). In this regard, variability is among key sources of risk in production process in Tanzania (Moshi et al., 2017). Hence, the performance of the introduced chicken strains is likely to suffer from the same problem, hence exposing farmers to risk. Additionally, agricultural performance variability also creates significant challenge in the design and implementation of technology (De Janvry, 1972; Chavas and Shi, 2015).

Recently, Tanzania established the Tanzania Livestock Master Plan (TLMP) 2017/2018-2021/2022 with the overall target of raising annual chicken meat production almost eightfold; from about 60 800 to 465 600 tonnes and egg production from about 3.0 to 4.2 billion by year 2021/22(URT, 2017). The main pathways include: Improved Traditional Family Chicken (ITFC), Tropical Improved Chicken (TIC) and expanded Specialized/Commercial Chicken (SCC) with layers and broilers sub-systems. In addition, the Master Plan considers interventions in the areas of animal health, genetics, marketing and processing being the cornerstone to increasing the contribution of the poultry sub-sector to the Gross National Product (GNP) by 182 percent in 2017 to nearly USD 324 million in 2022. In supporting the established initiative, the ACGG project introduced two chicken strains for on-farm testing to evaluate their economic potential at farm level in different agro ecological zones. The introduced strains are Kuroiler and Sasso, which have performed better in terms of growth rate and egg production than local strains in other countries including Ethiopia and. The Kuroiler strain, which is developed and marketed by Kegg farms, weighs about 1.8–1.9kg (hen) and 2.3–2.4 kg (cock) at 20 week age (cock) and a hen can produce about 150 eggs per year (World Society for the Protection of Animals, 2011). The Sasso strain, which originally was developed and marketed by Hendrix Genetics weighs 1.5-1.7 kg (hen) and 2.2-2.5kg (cock) at 20 week age and can produce about 150 eggs per hen per year (Rodelio and Silvino, 2013). However, the performance of the introduced strains may be unstable due to variability that emanates from input use, thus exposing farmers to production risk. As noted by scholars (Simon, 1959; Hurd, 1994; Fufa and Hassan, 2003; Khayyat and Heshmati, 2014), variability in agricultural production is one of the major sources of risk. Moreover, some endorsed innovations may be so risky to the extent that added risk offsets the gain in income leading to worse the livelihood outcomes among farmers (Richardson et al., 2008). Facing variability in production, farmers will try to mitigate the risks through input choices (Tveteras et al., 2011), since such input choices play a great role in determining variability in performance (Antle, 1983).

The analysis intended to reveal the effect of controllable inputs on production and variability of the introduced chicken strains in selected areas in Tanzania. This is because ignoring effect of inputs on performance variability in assessing the economic potential of agricultural technologies can lead to wrong inferences and recommendations (Koundouri and Nauges, 2005). The analysis is useful to farmers through increased knowledge on the effect of input choices on performance variability for improves production stability. Furthermore, it follows that the outcome of this study is important when the re-designing and scaling up the introduced chicken strains. The study is guided by the hypothesis that, input factors do not significantly influence the production and variability of introduced chicken strains with respect to controllable inputs.

THEORETICAL FRAMEWORK

The study was based on the Just and Pope (1979) production function expressed as the summation of the mean and variance functions. It is widely recognized that agricultural products are stochastic and levels of inputs used influence variance of the output (De Janvry, 1972; Fufa and Hassan, 2003). To account for variability, the Just-Pope framework is used as a standard framework that can perform joint estimation of both the mean and variance functions (Just and Pope, 1979; Khayyat and Heshmati, 2014). The framework provides a method for estimating the effect of inputs on production and production variability. The production function is capable of evaluating; i) the effect of inputs on the mean level of output and ii) the effects of inputs on variability in yield (Just and Pope, 1979; Fufa and Hassan, 2003; IFPRI, 2006; Guttormsen and Roll, 2013).

The basic concept introduced by Just and Pope was to construct the production function as the sum of two components, one relating to the output level, and one relating to the variability of output to provide a convenient and flexible representation of the effects of inputs on means and variances (IFPRI, 2006). The model is also appropriate for analysing the risk effects of inputs on output distribution in cross sectional, time series and a combination of time series and cross sectional production data (Fufa and Hassan, 2003).

In analysing the effects of inputs on production variability, it is important to start investigating whether there is any significant output variability (Asche and Tveteras, 1999). To test the presence of production variability one can draw from the Just and Pope (1979) theoretical framework whereby variability is determined in terms of heteroskedasticity (Asche and Tveteras, 1999; Fufa and Hassan, 2003; Guttormsen and Roll, 2013). The current study applied the Maximum Likelihood (ML) Breusch-Pagan test to assess the existence of variability in both chicken and eggs production for Kuroiler and Sasso strains among farmers participating in the ACGG study.

METHODOLOGY

Research Design

A developmental research design was applied for establishing on farm testing and then to analyse the technical, allocative and economic efficiency of keeping introduced chicken stains. The design assumes a traditional model of skill in which the unit of analysis is taken to be the individual (AFNETA, 1992; Richey, 1994). According to Barrow and Röling (1989), the development and transfer of appropriate technologies should be a function of the farmers‘ socio-economic and management practices at the field level. The study design is in accordance to Thornton et al. (2017) that testing and dissemination of technology are at the core of development-oriented agricultural research. Selection of location for establishing on-farm testing was based on Tanzania‘s Agro Ecological Zones (AEZs) to present the general farming systems in Tanzania.

The AEZs range from higher rainfall areas on the coast and highlands in the north, far west, south and southwest, to arid and semi-arid areas in the interior of the country (URT, 2015). Accordingly, cropping patterns, climatic differences reflect biophysical characteristics for growth and stability of chickens. On-farm testing for introduced chicken strains across different AEZs was meant facilitating farmers and other actors in poultry value chain evaluate the potential of the strains at farm level.

Three assumptions underlie the design. First, selected farmers had have experience in keeping chickens so that the design does not add any fixed cost such as chicken house, feeding facilities and drinkers. In other words, on-farm testing used already available facilities. Secondly, time and labour spent in keeping introduced chickens and available local chickens were presumed similar and hence zero opportunity cost. Third, small-scale local farmers in Tanzania operate relatively similar in keeping chickens. Thus, any of AEZs fit for on-farm testing. According to ACGG (2015), households recruited to receive the chickens met the following criteria:

i. Chicken keeping households that had kept local chickens for a continuous period of at least two years prior to the baseline survey;
ii. Keeping at least 15 adult chickens but no more than 50;
iii. Willingness to accept 25 birds of randomly selected strain;
iv. Commitment to provide some supplemental feeds and
v. Willingness to participate in the project for a minimum of 72 weeks.

Setting the basic criteria for selecting farmers to participate in on-farm testing, the baseline survey was conducted. Baseline survey was conducted to identify legible population in central semi-arid, eastern sub-humid, southern highlands, lake zone and southern humid to represent different agro-ecologies in the country. Specifically, first step involved selection three regions and the selected ones were Morogoro, Dodoma and Njombe regions to present AEZs.

In each region, one district was selected purposely taking into account the availability of villages which had about 20 and above households that have least 15 adult chickens but no more than 50. Secondly, out of the qualified villages, four of them from each district were selected randomly from the long list of villages. Subsequent stage involved randomly selection of households from the long list of households that met the set criteria. After random selection of qualified farmers, it followed provision of six-week pre-brooded chicks to these households whereby each farmer received 25 chicks. At this stage, each farmer received either Kuroiler or Sasso. Chicks received the recommended vaccination against Mareks, Newcastle Disease, Infectious Bronchitis and fowl pox before being distributed to farmers. Farmers continued keeping these strains based on their practices with some additional supplementation using locally available feeds and providing treatment and shelter under a semi-scavenging system (ACGG, 2016).

Description of Study Area

This study was conducted in three regions where farmers were participating in on farm testing of introduced chicken strains in Tanzania that is Dodoma (central), Morogoro (eastern zone) and Njombe (Southern highland) whereby in each region one district was selected. Dodoma is a semi-arid region, which lies on Latitude 6°48`S and Longitude 39°17`E and an altitude of 1125M above sea level. Annual rainfall is about 500 to 700mm and annual average temperature of about 22.6°C. Between the driest and wettest months, the difference in precipitation is 129 mm and the average temperatures vary by 5.1°C (Climatic Data Org, 2016). The common crops grown include drought tolerant crops like family of sorghum, groundnuts, sunflower, and little maize. In Dodoma region, on farm test sites were located in four villages namely Mayamaya, Bahisokoni, Mudemu and Mpamatwa in Bahi district.

Morogoro region is located between latitude 5°58` 10°0`S and longitude 35°30`E and an altitude of about 525M above sea level. The annual rainfall ranges from 600 to 1200 mm with average annual temperature of about 25°C. The zone is characterized by an average annual rainfall of 1160 mm with average temperature of 16°C. There are typically two distinct long and short rainy seasons of March–May and November–January/February, respectively, but rain sometimes falls uninterrupted from October to March. The Udzungwa and extensive river system have deposited rich alluvial sediments in the valley (Climatic Data Org, 2016). Rice and maize production, horticultural produces and bananas dominate the production system in Ifakara district council. Villages in which farmers participated in ACGG project include Kibaoni, Kikwelila, Lipangalala and Lumemo.

Njombe region is located between Latitude 8°51`0`S and Longitude 34°50′0`E and an altitude of about 2000M above sea level. Its climate is classified as warm and temperate. In winter, there is much less rainfall than in summer. The average annual rainfall is 1160 mm with average temperature of 18.6°C (Climatic Data Org, 2016). Maize, sunflower, pulses and horticultural production dominate farming system of the site. Wanging`ombe district was purposively selected among district forming Njombe region hereby farmers from Ujindele, Uhambule, Msimbazi and Ufwala villages were involved to provide data used in this study.

Data Collection

Data used in analyses for this study were collected from local chicken farmers participating in the ACGG project at the chosen sites. A total of 202 participant households from 12 villages were involved in the study. Out of the total famers, 111 farmers were Sasso strain keepers whereas 91 farmers were Kuroiler chicken keeping households. Data were collected through weekly recordings, survey and observation. Direct observation was applied to access the quality of the chicken house and accessories. The survey covered broad issues related to the chicken enterprise: viz. the number of chickens, number of eggs sold, ready for selling, number of chicks/chicken sold and ready for sale, amounts and prices of feeders, brooder, chicks, eggs, feeds, medication and labour), number of chicken/chicks which died and the cost of constructing the chicken house.

The following elements of improved poultry housing were used to assess housing structure of participating households: (i) ventilation status and orientation; (ii) spacing requirement of chicken; (iii) floor status; (vi) roof status (spillage); (v) presence of feeder and drinkers; (vi) presence of litter/bedding material; (vii) general hygiene status. The housing structure in this context was not necessarily built using expensive materials to be ranked high but rather to meets the basic requirements regardless of construction materials used (Pius and Mbaga, 2018). Thus, from the developed scale, poultry houses were ranked with three levels; a house scored between 1 and 3 as rated poor, between 4 and 5 and between 6 and 7 was rated normal/moderate and good house respectively.

Data Analysis

A Multivariate multiple regression model in the Just and Pope framework was applied to determine the effect of inputs on production and variability using Stata version 13 software. Multivariate multiple regression model is an extension of the standard multiple linear regression model. The model is used when a problem consists of two or more predictor variables and two or more response variables (Cassandra, 2013 and Dattalo, 2013). The multivariate regression model for each response on the ith observation is presented in equation 5.1, where i=1, 2,… n, represent the number of farmers or respondents.

$$\left\{ \begin{array}{l} Y_{i1} = \beta_{01} + \beta_{11}X_{i1} + \beta_{21}X_{i2} + \ldots + \beta_{r1}X_{ir}) + u_{i1} \\ Y_{i2} = \beta_{02} + \beta_{12}X_{i1} + \beta_{22}X_{i2} + \ldots + \beta_{r2}X_{ir}) + u_{i2} \end{array} \right\} \quad (1)$$

Where Y_1 is the sum of chickens sold, consumed, available, Y_2 is total number of eggs produced, X_i is the inputs used in production process such as maize bran, rice bran, cakes, vegetable and fishmeal and u_{i1} and u_{i2} are random errors for chicken and eggs respectively.

Multivariate multiple regression in the Just and Pope stochastic production function can be represent as follows:

$$y = g(x, v) \tag{2}$$

where y is output, x is a vector of controllable inputs such as feeds, and medicines, v is a vector of non-controllable inputs such as weather conditions, and g(x, v) denotes the largest feasible output given x and v. The Just and Pope (1979) production framework can be expressed as follows:

$$g(x, v) = f(X, \beta) + [h(x, \theta)]^2 e(v) \tag{3}$$

Where, f(.) is mean production function, h(.) is variance (or risk) function, x = vectors of inputs, β and θ are parameters for the mean function and the risk function respectively; and e is the exogenous stochastic disturbance or production shock (error term). This specification allows differentiating the impact of inputs on output and risk, and has sufficient flexibility to accommodate both positive and negative marginal risks with respect to inputs. Further, the model allows first test for the presence of production risk and if production variability is found to be present, the mean and risk (variance) functions are estimated separately (Asche and Tveteras, 1999). Specifically, multivariate multiple regression can be specified as in equation 4:

$$\left\{ \begin{array}{l} g_1(x, v) = f_1(X, \beta) + h_1(x, \theta)e(v) \\ g_2(x, v) = f_2(X, \beta) + h_2(x, \theta)e(v) \end{array} \right\} \tag{4}$$

Whereby 1 is Just and Pope Function for chicken and 2 is Just and Pope egg production function.

It follows that, the decision as to which type of production function to be applied is made at two levels: first, at the review of production functions and second at the empirical level. At the review level, the Just and Pope

Framework requires that, heteroskedasticity (variability indicator) is non-linear, so its estimation must use a nonlinear function (Just and Pope, 1979). The later was done using a likelihood test of different models such as the Quadratic function, Square root functions, the Translog and both Log and Semi log functions. In likelihood procedure, the semi log production function was found to be superior. The Semi log production functions for both mean and variance production functions are presented as follows:

$$\ln Y_{i1} = \beta_{01} + \beta_{11}X_{i1} + \beta_{12}X_{i2} + \beta_{13}X_{i3} + \beta_{14}X_{i4} + \beta_{15}X_{i5} + \beta_{16}X_{i6} + \beta_{17}X_{i7} + \beta_{18}X_{i8} + \beta_{19}X_{i9} + \beta_{110}X_{i10} + \beta_{111}X_{i11} + e_{i1}$$

$$\ln Y_{i2} = \beta_{02} + \beta_{21}X_{i2} + \beta_{22}X_{i2} + \beta_{23}X_{i3} + \beta_{24}X_{i4} + \beta_{25}X_{i5} + \{\beta_{26}X_{i6} + \beta_{27}X_{i7} + \beta_{28}X_{i8} + \beta_{29}X_{i9} + \beta_{210}X_{i10} + \beta_{211}X_{i21} + e_{i2}\} \quad (5)$$

and the risk function is given as follows:

$$\ln \hat{u}^2_{i1} = \theta_{01} + \theta_{11}X_{i1} + \theta_{12}X_{i2} + \theta_{13}X_{i3} + \theta_{14}X_{i4} + \theta_{15}X_{i5} + \theta_{16}X_{i6} + \theta_{17}X_{i7} + \beta_{18}X_{i8} + \beta_{19}X_{i9} + \beta_{110}X_{i10} + \beta_{111}X_{i11} + v_{i1}$$

$$\ln \hat{u}^2_{i2} = \theta_{02} + \theta_{21}X_{i1} + \theta_{22}X_{i2} + \theta_{23}X_{i3} + \theta_{24}X_{i4} + \theta_{25}X_{i5} + \{\theta_{26}X_{i6} + \theta_{27}X_{i7} + \beta_{28}X_{i8} + \beta_{29}X_{i9} + \beta_{210}X_{i10} + \beta_{211}X_{i11} + v_{i2}\}$$

Where Y_1=number of chickens (available, sold and consumed) for the ith farmer, Y_2=number of eggs, β_0 and γ_0=Constants, β and θ =unknown estimates for production and variability respectively, e_(i1) ande_(i2)=random errors, X1=amount of maize bran (kg)/annum, X2= amount of rice bran(kg)/annum,X3=amount of sunflower cake(kg)/annum, X4=amount of fishmeal (kg)/annum, X5=Minerals (kg), X6=Number of bundles of vegetables, X7=Frequency of providing medication, X9=House condition (defined as poor, normal, good), X10=Labour (number of hours spent, X11=Location, u ̂_i2^2 and u ̂_i2^2are variance (risk) for chicken and eggs respectively. Yield (Yi) and the yield variance ($\hat{U}^2$) are estimated using equation 6 and 7 respectively. The decision as to which type of production function to apply was made at two levels: at review of production functions and at the empirical level. At the review level the Just and Pope Framework recommends that heteroskedasticity (variability indicator) is non-linear, so its estimation must use a nonlinear regression (Just and Pope, 1979). The later was done by a likelihood test of different models like Quadratic function, Square root functions, Translog and both Log and Semi log functions. The dependent logged semi log function was found to be superior to the rest. The Semi log production functions for both mean and variance production functions are presented as follows:

$$\left\{ \begin{array}{l} \ln Y_{i1} = \beta_{01} + (\sum X_{1-13})\beta'_1 + u_1 \\ \ln Y_{i2} = \beta_{02} + (\sum X_{1-13})\beta'_2 + u_2 \end{array} \right\} \quad (6)$$

and the yield variance function is given as follows:

$$\left\{ \begin{array}{l} \ln u^2_{i1} = \gamma_{01} + (\sum X_{1-13})\gamma'_1 + v_1 \\ \ln u^2_{i2} = \gamma_{02} + (\sum X_{1-13})\gamma'_2 + v_2 \end{array} \right\} \quad (7)$$

where Y_i = the number of chickens/eggs sold and available for sale for i farmer, β_0 and γ_0 = Constants, β and =Unknown estimates, e_i = random errors, X_1 = Maize bran (kg), X_2= Rice bran (kg), X_3=Sunflower cake(kg), X_4 = Fishmeal (kg), X_5 = Minerals (kg), X_6 = Number of bundles of vegetables, X_7 = Frequency of vaccinations, X_8 = Frequency of treatment, X_9 = House condition, X_{10} = Labour, X_{11} = Ifakara, X_{12} = Wangingòmbe, X_{13}= Bahi, and u^2_{ij}= variance (a measure of variability).

RESULTS AND DISCUSSIONS

Growth of Chickens across Agro-Ecological Zones

The average weight gains of the strains (Table 1) indicates that, an average weight of Sasso cockerels in 22 weeks was about 2216 ± 41, 2102 ± 70 and 2090 ± 14g in Wanging‘ombe, Ifakara and Bahi respectively. Similarly, the body weight of Kuroiler strains recorded were 2197 ± 51, 2070 ± 53 and 2121 ± 50 in Wanging‘ombe, Ifakara and Bahi respectively. Table 1 details the weight gain of introduced chicken strains across the agro ecological zones and sex.

Table 1. Growth of introduced chicken males across agro-ecological zones (g) (Mean ± SD)

Age/Zone	**Wangingòmbe**	**Ifakara**	**Bahi**
Weight (Kg)	Male	Male	Male
Sasso strain			
Week 6	1137 ± 11	1102 ± 39	1283 ± 10
Week 10	1257 ± 18	1385 ± 74	1328 ± 12
Week 14	1763 ± 29	1401 ± 44	1762 ± 20
Week 18	1911 ± 27	1927 ± 41	1978 ± 147
Week 22	2166 ± 41	2102 ± 70	2090 ± 14
Kuroiler strain			
Week 6	1127 ± 43	939 ± 58	1028 ± 41
Week 10	1373 ± 35	1385 ± 74	1373 ± 35
Week 14	1710 ± 36	1680 ± 38	1710 ± 36
Week 18	1920 ± 34	1913 ± 26	2097 ± 51
Week 22	2197 ± 51	2070 ± 53	2121 ± 50

Egg Production

The results (Table 2) indicate that for Sasso strain, on average total eggs produced per birds during the production cycle ranged from 20 to 109 eggs with a mean of 48, 45 and 59 eggs in Bahi, Ifakara and Wanging‘ombe respectively. On the other hand, the egg production for Kuroiler strain indicates that eggs per hen ranged between 16 and 95 per production cycle. Like Sasso strain, Wanging‘ombe sites showed the highest production performance with average of 53 eggs per chicken while Ifakara sites were the least with an average of 41 eggs per annual. The egg production differences were found to be statistically different across the selected sites (P Value = 0.000).

Table 2. Egg Production across agro-ecological zones per hen per 12 months

Sites	**Egg production**		
	Minimum	Average	Maximum
Sasso strain			
Ifakara	21	45	78
Wangingombe	23	59	95
Bahi	20	48	109
P Value			0.000
Kuroiler strain			
Ifakara	16	41	78
Wangingòmbe	21	53	95
Bahi	18	49	86
P Value			0.000

Survival Rate

Table 3 illustrates the mortality of introduced chicken strains at farm level in the selected areas. The average cumulative mortality recorded at farmer level, after 6 weeks old until the age of 68 weeks was 27.0 and 27.1% on Sasso and Kuroiler respectively. The mortality of Sasso strain is somehow higher than the mortality recorded Ethiopia whereby mortality at farmer level condition after 45-day old till the age of production was 25% (Getiso et al., 2017). The highest mortality was observed at the age between 26 and 42 weeks. Kuroiler and Sasso strain showed the highest mortality rate of 5% and 3.5% between 26 and 42-week age. Farmers and extension officers reported the signs of egg peritonitis and related infections as the plausible causes of mortality between that age intervals. Egg yolk peritonitis is the inflammatory reaction of peritoneum caused by the presence of yolk material in the coelomic cavity (Srinivasan et al., 2013). Accordingly, (Srinivasan et al., 2013) report that egg peritonitis was responsible for 15.39% of the reproductive tract abnormalities in commercial layers between 21 and 80 week of age. Other recorded causes of mortality include diarrhoea, Cannibalism, Coryza, fowl cholera, typhoid, toxic, accident and respiratory infections. Generally, the total mortality was found to be 27 and 27.1% for Sasso and Kuroiler respectively.

Table 3. Mortality of introduced chicken strains for 66 weeks

Age (Week)	**10**	**14**	**18**	**22**	**26**	**30**	**34**	**38**
Kuroiler	0.002	0.013	0.017	0.022	0.016	0.023	0.035	0.049
Sasso	0.024	0.025	0.027	0.013	0.007	0.030	0.011	0.033
Age (Week)	42	46	50	54	58	62	66	P Value
Kuroiler	0.036	0.008	0.017	0.006	0.015	0.011	0.27	0.52
Sasso	0.011	0.019	0.019	0.014	0.016	0.022	0.271	

Mean Yield Function Results

The estimated results for the mean response function for chicken production (live bird and egg) in study sites are given in Table 4. The factors affecting yield were quantity of maize bran, quantity of rice bran, quantity of sunflower cake, minerals, frequency of medication, vegetables and house condition. The results show that, for maize bran, the coefficient is positive for chicken production as well as in egg production. The elasticity of mean production for Sasso chicken and Kuroiler with respect to maize bran was 0.0007 and 0.0073respectively ($p<0.05$). This implied that maize bran has a positive effect on increasing production in both chicken strains. In addition, 1% increase in the use of maize bran by significantly ($p<0.05$) increased egg production by 0.0016% and 0.0009% for Sasso and Kuroiler respectively. Accordingly, maize bran is the main feed supplement in rural chickens keeping and greatly impacts production since it is a key in determining the nutrient intake levels (Mbajiorgu et al., 2011).

Table 4 shows that, the elasticity of chicken production with respect to rice bran was positive (0.0009) and (0.0120) implying that a 1 percent increase in feeding rice bran supplement increase chicken production by 0.0009 and 0.0012% in Sasso strain and Kuroiler strain respectively.

However, there was no significant difference ($P<0.05$) between Sasso and Kuroiler for the effect of rice bran on production. The results are consistent with the result by Samli et al. (2006). In their experimental research, they revealed that rice bran was very important for chicken growth and egg production.

Sunflower cake supplement was found to influence chicken production ($P<0.005$) for Sasso strain. The results indicate that increase in provision of sunflower cake increased Sasso production by 0.0008%. However, in Kuroiler chicken and in both eggs production, the effect was not significant. Also minerals significantly influenced egg production in both introduced strains. As indicated in Table 4, 1% increases in sunflower provision significantly increased eggs production in Sasso strain by 0.01% ($P<0.005$) while in Kuroiler strain increased by 0.1089% ($P<0.1$).

The regression coefficients of medication in both chicken strains are positive implying that the increasing treating and vaccinating the introduced chicken strains contributed much on the rising production performance. The coefficients of medication for chicken production have positive sign, although not significant, which implies that there was likelihood of impacting on production. Further, the coefficients of medication on egg production had significant impact on egg production ($P<0.05$). As indicated in Table 4, 1% increases in frequent provision of medication increased egg production by 0.022% and 0.0315 in Sasso and Kuroiler respectively. The results are consistent with Verbeke et al. (2015). In their analysis, they concluded that the health of livestock is the critical determinant of the success of a livestock business. The addition of the cost of medication/vaccines makes the chickens in a healthy condition and be able to utilize feed consumed to support production optimally. Additionally, Thomsen (2005) indicated that farmers recognize vaccination as the most effective means of combating disease for improving egg production.

Fishmeal is a high quality animal feed used to provide a good balance of essential amino acids, energy, vitamins, minerals and trace elements for poultry (Frempong et al., 2019). On the contrary, fishmeal was found to have insignificant effects on both live chicken and egg production.

According to Cho and Kim (2011), researchers have demonstrated that including fish meal in chicken feeds result in better growth performance. However, limited availability, low rate use and timing are very crucial to realise its impact (Babu et al., 2005). Consistently, results in Table 5 indicate that very few farmers fed their chicken with fishmeal.

Table 4. Mean production function for chicken and eggs

Variable	Chicken Production		Egg production	
	Sasso	**Kuroiler**	**Sasso**	**Kuroiler**
Maize bran (kg)	0.0007***	0.0073***	0.0016**	0.0009**
Rice bran (kg)	0.0009**	0.0120**	0.0020**	0.0016*
Sunflower cake (kg)	0.0008**	0.0007*	0.0001	0.0001
Fishmeal	0.0020	0.0018	0.0030	0.0041
Minerals	0.0029	0.0029	0.0100**	0.1089*
Vegetables	0.0007	0.0008	0.0010*	0.00130
Frequency of medication	0.0057	0.0045	0.022***	0.0315***
Sites				
Ifakara	-0.0273	-0.0424	-0.574	-0.6341
Wanging'ombe	-0.0740	-0.0140	-0.159	-0.1875
House condition				
Good	0.099**	0.9332*	0.022**	0.6963*
Normal	0.0423	0.0413	0.045	0.1336
Labour	0.6120	-0.3216	0.1623	0.0916
Constant	1.2588***	1.6600***	2.411***	3.1638***
R^2	0.26	0.23	0.33	0.31

Significance levels are denoted by one asterisk (*) at the 10 percent level, two asterisks (**) at the 5 percent level, three asterisks (***) at the 1 percent level.

The coefficient for the chicken house condition (Table 4) is positive and statistically significant from zero in both Sasso and Kuroiler chicken production and in Sasso only in egg production. Chicken kept in a house rated good, performed better relative to poor house. Sasso strain kept in the good house performed better than the same strain kept in poor house with elasticity of 0.0990 while Kuroiler stain kept in good house performed better with elasticity of 0.0220 relative to the strain kept under poor condition house. The results are consistent with Oloyo and Ojerinde (2019) who asserted that, poultry housing condition is very crucial to protect the birds from the harsh environmental climatic conditions, which may have adverse effect on the chickens' performance and productivity. However, the results are inconsistent with that of Montero et al. (2011) who reported that there was no significant influence of house condition on chicken and egg differences.

Table 5. Summary statistics for feeds supplement for 12 months

Statistics	Maize bran (kg)	Rice bran (kg)	sunflower cake (kg)	Fishmeal (kg)	Minerals (kg)	Vegetables (bundle)
Kuroiler strain						
Mean±SD	7.5±4.6	6.6±3.6	1.8±1.8	0.6±0.6	0.5±0.6	2.3±0.9
% of farmers	100	63	64	37	52	19
Sasso strain						
Mean±SD	9.5±5.0	5.2±2.1	3.1±2.2	0.9±0.7	0.6±0.6	3.2±3.0
% of farmers	100	16	51	15	30	24

Testing for Performance Variability

First, a hypothesis was carried out to test for the absence of input oriented performance variability (homoskedasticity) in chickens and eggs production in the two strains. As indicated in Table 6, the χ^2 values in all four cases are statistically greater than the corresponding χ^2 Critical values, resulting in P values are less than 0.05 (critical value). Thus the hypotheses of homoskedasticity in chicken performances variability are rejected and hence confirming that there is existence of inputs caused variability in performance. The finding on presence of performance variability conforms to that of Vaidyanathan (1992) who noted that agricultural technologies, even as they help to raise yield, also lead to great instability in output in terms of variability and hence creating risks to farmers. Further, Yang et al., (2016) who explained that yield variability in production is influenced by choice of input combinations as detailed in the subsequent discussion.

Table 6. Testing for evidence of performance variability

Chicken	**Hypothesis**	**Critical Value**	**Statistics**	**P-Value**
Kuroiler- Birds	$e^2_{ikb} = \sigma^2_{kb}$	4.485	39.21	0.000***
Kuroiler-Eggs	$e^2_{ike} = \sigma^2_{ke}$	2.697	28.47	0.003***
Sasso –Birds	$e^2_{isb} = \sigma^2_{isb}$	8.08	55.21	0.000***
Sasso –Eggs	$e^2_{ise} = \sigma^2_{ise}$	2.25	23.98	0.014**

Notes: e^2-variance, kb-Kuroiler Bird, ke-Kuroiler eggs, sb-Sasso Birds, se-Sasso eggs.

Effect of Inputs on Performance Variability

Results of the specification of the J-P variance function shows both decreasing and increasing effects of inputs on chickens and eggs performance variability in the two strains (Table 7). Variability in performance of introduced chicken strains was not well explained by the controllable input factors under consideration as indicated by the low R^2 value (Table 7). The reason for this is that some of factors were beyond the researchers` control. These factors include scavenging for household scraps, rainfall, temperature and diseases incidences, which have strong influences on performance variability (Zaghari et al., 2011; Rust and Rust, 2013; Rekwot et al., 2016).

Provision of maize bran was found to significantly ($p<0.05$) increase the variability of chicken and egg production in both chicken strains. A one percent increase in maize bran consumption increased chicken performance variability by 0.016 and 0.009 percent in Sasso and Kuroiler strains respectively. The results imply that increase in quantity of maize bran was more likely to increase production risk. This might be because these farmers depended heavily on the feed and hence over utilizing it relative to other feed ingredients.

However, egg production variability showed contradicting results; where maize bran feed ingredient increased variability with increasing input use in Sasso strains while variability decreased with increase in maize bran feeding in Kuroiler strains. Further, the results on egg production variability were insignificant, providing weak evidence that provision of maize bran leads to significantly influencing egg performance variability. Meanwhile, the use of rice bran did not significantly decreased performance variability for Sasso strains performance in both birds and eggs, but rice bran appears to have a significant ($p<0.05$) effect on the level of variability, with an elasticity of 0.009 percent for Kuroiler birds.

Sunflower cake was found to be a variability increasing input as the results show that a one percent increase in sunflower cake feeding, increases performance variability of Sasso birds by 0.0254 percent ($p<0.001$). However, sunflower cake did not affect performance variability of Sasso eggs, and Kuroiler eggs and birds. Though not significant, Fishmeal was found to be the only input factor with a sign of the variability decreasing effect in both live birds and egg production performances in both strains.

Vegetable supplementation indicates results (Table 7) whereby one percent changes in vegetable supplementation increased significantly performance variability by 0.035 percent in Kuroiler egg production while in rest cases the effect on production variability was not significant.

The results (Table 7) further showed that medication had a negative and significant effect on the production variability of egg production for both chicken strains. This implies that, farmers who treated their chickens timely increased egg production stability and hence reducing the risk that farmers in that area face. The coefficients for medication with respect to egg production were -0.1020 and -0.336 ($p<0.1$) and significantly different from zero, which means they had a risk reducing effect for Sasso and Kuroiler chicken strain respectively. This is consistent with Sodjinou (2011) and Thomsen (2005), who argued that good timing for vaccination and treatment reduced death rate amongst several birds and hence high contribution to variability decreasing. Nevertheless, frequency of medication showed the signs of variability increasing in Sasso and Kuroiler bird production.

House condition was found being variability decreasing significantly for Kuroiler chicken production but with a sign of variability decreasing in egg production in both strains while it showed the sign of variability increasing in Sasso bird production. The decreasing sign implies that house condition was important in reducing variability such that farmers with poorhouse conditions were more likely to have poorer production compared to those with good house.

Table 7. Effect of inputs on production variability of introduced chicken strains

	Chicken production		Egg production	
	Sasso	**Kuroiler**	**Sasso**	**Kuroiler**
Maize bran	0.0167***	0.009***	-0.0031	-0.007
Rice bran	-0.0069	0.009**	-0.0069	0.009
Sunflower cake	0.0254***	0.007	0.0031	0.021
Fishmeal	-0.0745*	-0.033	-0.0249	-0.038
Minerals	-0.0079	0.01***	0.0369*	-0.001
Vegetables	0.0004	-0.002	-0.0004	-0.035***
Frequency of medication	0.0494	0.015	-0.1020*	-0.336**
House condition				
Good	0.0496	-0.16***	-0.0037	-0.106**
Normal	-0.0413	0.054	0.0589	-0.170
Labour	0.832	-0.246	0.1237	-0.077
Agro-ecological zone (sites)				
Ifakara	0.7200	0.0933	-0.746	0.124
Wangingòmbe	0.5347	-0.1636	-0.0300	1.073
Constant	1.5821***	1.8710***	2.6120***	3.4713***
R^2	0.49	0.21	0.43	0.31

Notes: statistical significance levels: ***1%; **5%; *10%. Corresponding P value standard errors are shown in parentheses.

while in Sasso, it showed variability increasing. For variability decreasing, this study results are consistent with results by Fufa and Hassan (2003) who reported that the coefficient for labour was insignificant with positive and negative effect to production and variability respectively. Contrary, Wanda (2009) reported that labour was negatively related to yield variability of a crop production in Uganda.

Lastly, the location had no effect on the production variability for both birds and eggs and in either strain. This implies that location specificity does not influence performance variability in both strains. On the contrary, study by Meon and Weill, (2005) found that geographical location contributed much on the performance and performance variability.

CONCLUSION AND RECOMMENDATIONS

The results indicate that controllable inputs had effects on both performance and variability. Controllable factors having the effect included were quantity of maize bran, quantity of rice bran, quantity of sunflower cake, minerals, and frequency of medication, vegetables and house condition. Some inputs were both variability increasing and reducing; reducing in production of birds but increasing in egg production for the same strain and vice versa, although many inputs were not significant. Overall, the study rejected the null hypothesis that input factors do not influence variability in production of the strains implying that they do have such influence. Nevertheless, it is likely that the full potential of the introduced strains requires inputs in the form of husbandry. It is important to design strategies that will lead to yield stability. Such strategies should include the design of trials at farm level to evaluate the input mix with minimum effect on output variability.

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